

Radical and nucleophilic substitution reactions

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

How does the identity of the halogen and the structure of the carbon chain change how fast a halogenoalkane reacts? You will compare hydrolysis rates by timing the silver halide precipitate and then explain the pattern with bond enthalpies and the SN1 and SN2 mechanisms.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R3.4

Aim

To compare the rates of hydrolysis of halogenoalkanes with warm ethanolic silver nitrate, and to show how the halogen and the structure (primary, secondary, tertiary) control the rate.

Equipment

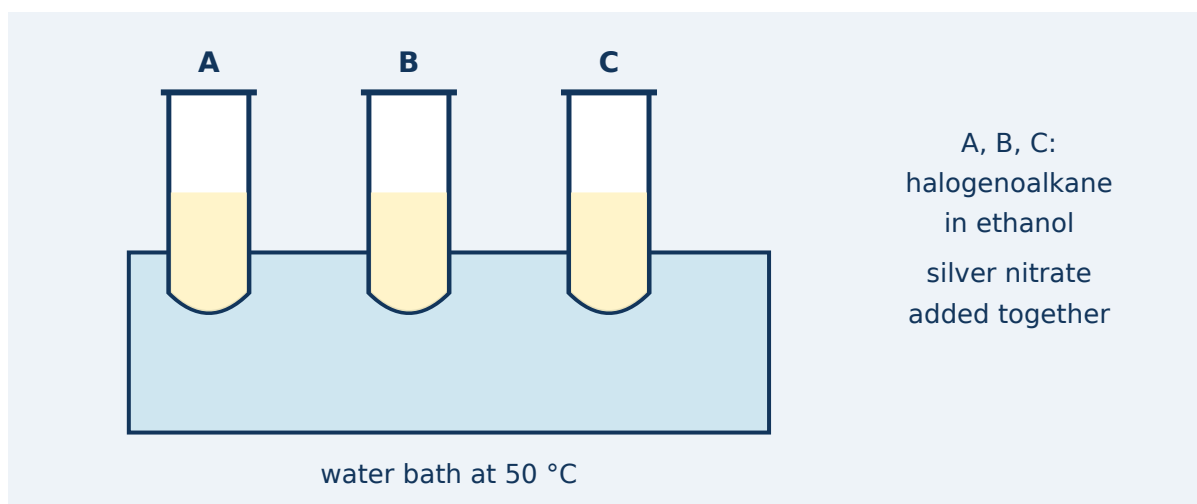
- 1-chlorobutane, 1-bromobutane, 1-iodobutane, 2-bromobutane, 2-bromo-2-methylpropane (about 5 drops each)
- Ethanolic silver nitrate (0.10 mol dm^{-3}), ethanol
- Test tubes, rack, 250 cm^3 beaker for a water bath at 50°C , thermometer, stopwatch, droppers

Safety

Safety

Wear goggles and gloves. Halogenoalkanes and ethanol are flammable and harmful: use a hot-water bath, never a naked flame. Silver nitrate stains skin black. Dispose of waste in the halogenated waste container.

Method



Three halogenoalkanes warmed in a water bath. A: 1-bromobutane; B: 2-bromobutane; C: 2-bromo-2-methylpropane.

1. Place 1 cm³ of ethanolic silver nitrate in each of five test tubes and stand them in the 50 °C water bath for 3 minutes.
2. Add 5 drops of one halogenoalkane to a tube and start the stopwatch at once.
3. Stop the watch when the first cloudiness appears. Record the colour and time. Stop at 600 s if nothing forms.
4. Repeat for each halogenoalkane. Keep the temperature, volumes and number of drops the same.

Results

Halogenoalkane	Type	Precipitate colour	Time (s)
1-chlorobutane	primary	none	> 600
1-bromobutane	primary	cream	62
1-iodobutane	primary	yellow	9
2-bromobutane	secondary	cream	24
2-bromo-2-methylpropane	tertiary	cream	3

Analysis questions

Question 1 Identify the precipitates

Name the precipitates formed from the chloro, bromo and iodo compounds, and write the ionic equation for the precipitate from 1-iodobutane.

Question 2 Effect of the halogen

Use the three primary compounds to describe how the rate changes with the halogen, and explain using bond enthalpies.

Question 3 Relative rates

Take 1-bromobutane as 1.0 and calculate the relative rate ($1 \div \text{time}$) of 1-iodobutane, 2-bromobutane and 2-bromo-2-methylpropane.

Question 4 Effect of structure

Describe the trend among the three bromo compounds and give the mechanism that explains the tertiary result.

Question 5 Controlled variables

State three variables that must be controlled and why the tubes are pre-warmed.

Question 6 Source of error

Give one source of error in judging the first cloudiness and a way to reduce it.

Question 7 Hydrolysis equation

Write the equation for the hydrolysis of 2-bromo-2-methylpropane in water.